

PSYCHOLOGICAL EFFECTS OF FASTING

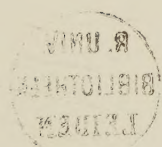
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PSYCHOLOGICAL EFFECTS OF FASTING

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THE EFFECTS OF PROLONGED FASTING

Problem. It was our purpose in the experiments here reported to study the psychological effects of relatively prolonged fasting. Three healthy adults, two men and one woman, went without food for from 10 to 33 days. Tests of several varieties were made at regular intervals before, during, and following the fasting periods.¹

*Earlier work on prolonged fasting.*² One of the well-known fasts of some length was that of Succi, reported by Luigi Luciani.³ During his 30-day fast Succi was observed only casually for effects upon mental processes. Other results, however, show that he made decisive improvement in test of strength. His firm belief in the efficacy of fasting may have affected the results. Luciani doubted Succi's sanity and had little faith in other than the purely physical results.

One of the recent experiments on fasting was reported by Marsh.⁴ This experimenter and his wife fasted for one week. The week preceding the fast they gradually reduced the amount of food taken, and the week following reversed this procedure. Short tests were used. The data secured during the control period were discarded for some unexplained reason. This period covered six days of testing, and should have been most significant for purposes of comparison.

The results secured in this experiment were not very definite. The experimenter thought there was some improvement in mental clearness and accuracy for both subjects. His conclusions about sex-difference have no value in view of the fact that only two subjects were used in the experiment.

The outstanding psychological experiment upon a long fast is that performed by Langfeld.⁵ The subject was Agostino Levanzin, a lawyer from Malta, who believed a fast markedly increases mental acuity. He claimed to have pleaded a case in the courts of law after having fasted for 26 days.

Levanzin came to this country for the express purpose of demonstrating the beneficial effects of fasting upon mental processes. He entered the Boston Nutrition Laboratory of the Carnegie Institute of Washington and underwent a 31-day fast there. Eight tests were given daily during the experiment, all comparatively short ones. Unfortunately, the experimenter had no opportunity to run a long series of preliminary tests. The follow-up tests had to be discontinued because the subject withdrew from the laboratory after developing a colic. The ailment was attributed to the nature of the food taken immediately after concluding the fast.

*Accepted for publication May 15, 1927.

¹This study was carried out in the Psychological Laboratory of the University of Chicago under the direction of Professor Edward S. Robinson.

²Experiments on short fasts are discussed at the end of this paper.

³Luigi Luciani, *Das Hungern*, tr. by M. O. Fraenkel, 1890.

⁴H. D. Marsh, Individual and sex differences brought out by fasting, *Psychol. Rev.* 23, 1916, 437-445.

⁵H. S. Langfeld, On the psycho-physiology of a prolonged fast, *Psychol. Monog.*, 1914, No. 71.

A year after the fast it was possible to test Levanzin again, but of course the time-interval involved was too great for the tests to throw any light on the process of recovery.

Levanzin showed a loss in muscular strength during the fast. Strength, as tested by the hand dynamometer, fluctuated from day to day, but showed a gradual falling off as the fast progressed. There was a gain in those tests involving the 'central processes'—by this phrase are meant tests of attention, perception, and association. Association and rote memory tests were also used, and several others. There was a decided gain in visual acuity as the fast progressed. At the end of the fast, Levanzin could detect the letter E, the largest one of the Snellen test card, in its correct position from twice the original distance.

The effects of practice in this experiment will never be clearly known. That there were practice effects is not denied. The most decisive facts brought out by the experiment were that muscular strength showed a falling off, and that the ability to improve mental operations through practice was not entirely arrested by the fast.

The lack of preliminary testing and a 'follow-up,' continuing for several days after a fast, has been a weakness of all previous experiments.⁶

Subjects. Three people were used as *Ss* in our experiment. They will be designated A, B, and C.

A is the writer's wife. She is a college graduate, and was engaged in the domestic duties of her household during the experiment. She did not prepare food for the family during the first few days of the fast, but found no difficulty in doing so after that. She fasted for 10 days.

A had undergone short fasts of a few days' duration several years previous to the present experiment, while attending college. She believed short fasts benefited her health, but she was not sure that they helped her mentally. She had never gone over 4 days without food before. Her previous fasts had been endured to get rid of very painful attacks of neuralgia.

She began the practice period on April 8, 1925, and was tested daily throughout the experiment. On May 18, 40 days after the first test, she began the fast. Testing continued during the fast as before. On the fifth day of the fast she developed a severe headache which continued for two days. She was in perfect health, as shown by physical and metabolic tests, preceding the fast. This was the only ill-health she experienced during the experiment. On May 27, after taking the tests, she concluded the fast. For 23 days after the fast, *i.e.* until June 19, testing continued. The entire testing period was 77 days in length. Further details are given below.

B, the writer, was a graduate student at the time of the experiment. He was pronounced in good health by an examining physician. Besides giving 5 hours daily, on an average, to the experiment, he carried two majors in the University—a course in experimental psychology and an advanced course in neurology.

B had never fasted before. He had no definite opinion about its mental and physical effects. He had read many claims about its rejuvenating effects and was interested in finding out what the results would be.

He began the practice period on April 25, 1925, and continued it for 32 days, or until May 27, the beginning of the fast. The fast was prolonged for 17 days, up to June 13. Testing was carried on daily throughout the entire experiment. The post-fast testing continued for 33 days, until and including July 15. The entire testing period was 82 days in length.

⁶Langfeld, himself, realized this deficiency in connection with his own study, but he was faced with circumstances which he was powerless to correct.

The health of *B* was good during the fast except for a slight headache on the tenth day. A physical examination on the fifteenth day of his fast showed him to be in excellent condition, except, of course, for the loss of flesh.

C is a man about 35 years of age. (All *Ss* were approximately the same age.) He had attained a secondary school education and is a lay scientist. He had fasted over a total of 300 days, previous to the present experiment, often in the interests of observing physiological effects. He had never taken psychological tests during a fast. He fasted 33 days for the present experiment. The longest fast that *C* had endured heretofore was one for 26 days. He had not undergone any fasts of over a few days length for several months previous to this experiment.

C believed that a fast improves one's health but doubted whether the results are worth the effort and inconvenience. He was quite certain that the "rational element," as he expressed it, is neither helped nor harmed by a long fast. He lived several miles from the psychological laboratory, and had to go back and forth from his home to take the tests. Fortunately, at this time, he was not employed in any occupation, and consequently could give considerable time to the experiment.

C began the practice period April 13, and was tested approximately every other day during the 110 days of the experiment. In only two instances were testing days less than a day apart. The greatest interval was two days, and it occurred several times. *C* took the tests 48 days out of the 110.

He was pronounced in good health at the beginning of the fast by a physician. On the 28th day of the fast he was given a cursory examination by a physician and was pronounced in good physical condition, despite rather extreme emaciation. Perhaps because he was accustomed to fasting, *C* found it unnecessary to take the twice-daily enema that the other *Ss* did as a matter of precaution. No biliousness nor other serious difficulty was encountered throughout his fast.

Nature of the tests. Seven tests in all were used during these experiments. They were selected with a view to making each task as difficult as possible. Where the task was not a difficult one the time-limit of performance was increased. None of the tests was of a purely muscular nature. Several were decidedly fatiguing. The reason will be evident in the following discussion.

Robinson and Herrman⁷ have shown that 3 *Ss* were able to perform in tests about as well after 60-65 hrs. of insomnia as they did normally. These experimenters tested for an interval from 11-26 days preceding the sleepless period. They followed the period of sleeplessness with 4 or 5 days of testing. Relatively short tests were used; the total time for five tests took from forty-five minutes to an hour. Inasmuch as the *Ss* doubtless put forth more effort during the period of insomnia, it was thought that we might partially offset this possibility by using tests that were rather fatiguing.

In another experiment on sleep Robinson and Robinson⁸ secured from their *Ss* ratings of the amount of effort that they felt they put forth in taking the tests. There were two groups, an insomnia and a control group. The experiment covered a period of three days. On the first day at the end

⁷E. S. Robinson and S. O. Herrman, Effects of loss of sleep, *J. Exper. Psychol.*, 5, 1922, 19-32.

⁸E. S. Robinson and F. R. Robinson, *ibid.*, 5, 1922, 93-100.

of the tests, 41% of the insomnia group felt that they had put forth their best effort. The night following was a sleepless one for the insomnia group. At the end of the tests, on the day after the sleepless night, 75% of them, as against 38% of the control group, felt that they had put forth their best effort. The insomnia group during the next 24 hours made up much of their lost sleep. On the third day only 49% of them, compared with 17% of the control group, felt they put forth their best effort during the tests.

These experimenters say: "The ratings of effort, considered in conjunction with those of tiredness, suggest that loss of sleep causes a general lowering of feeling tone accompanied by an increase of effort put forth upon a task. This increase of effort may so compensate for any ultimate loss in capacity that that loss may be relatively unobservable."

Further conviction along this line follows from the experiments of Kleitman⁹ on the effects of prolonged sleeplessness. His *Ss* went from 40 to 115 hours without sleep. He found no appreciable loss in the speed in naming 100 colors on a card. But when one *S* named 1200 colors (12 cards), Kleitman did obtain definite effects of insomnia.

After extensive investigation of various tests the following were selected.

(1) *Arithmetic*. Four hundred multiplication problems of two by two-place numbers were arranged from chance combinations of the digits 2-9 inclusive. Each two problems contained all of the digits. No digit occurred twice in the same problem. It was hoped that this would make the daily task fairly homogeneous. The problems containing the combinations 25 were eliminated because they suggested short-cuts. In a day's task no identical problems occurred. *A* solved 20 problems daily, and *B*, 40.

The multiplicand was first called out by *E*. It was repeated and written down by the *S*. In the same manner the multiplier was given, whereupon *E* immediately gave the signal, "Go." *S* gave the answer as quickly as possible without further writing. The correct answer was required. Time and errors were observed and recorded.

C thought he would be "forever" working off the effects of practice with so difficult a task. Consequently, and at his request, we constructed on the same principle 200 addition problems of 4x4-place dimensions. He performed 40 of these each day. The procedure was the same as for *A* and *B*, except that *C* wrote down the answers as he obtained them.

In this, as in the three tests that follow, *S* sat opposite *E* at a wide table. Between them was a screen, about 2 x 3 ft., supported on legs approximately 4 in. above the table top. It permitted *E* to observe what *S* wrote, or his general method of attacking a test. What *E* recorded was never observed by the *S*. Emotional distractions, due to the knowledge that one is being closely observed, are much more apt to be prevented by employing this simple device.

(2) *Writing*. The letters "ab" were written on uniform ruled paper for 20 min. as rapidly as possible. The *S* made a stroke on the line at the sound of a tap on the table every 30 sec. From the data obtained in this manner it was possible to construct fatigue curves for each of the periods. The errors were few enough to be negligible after several days of practice.

⁹N. Kleitman, The effects of prolonged sleeplessness in man, *Amer. J. Physiol.*, 66, 1923, 67-92; 67, 1923, 141-151.

The results consisted of the number of letters written during the 20 min. of the test. This type of activity had previously been used in connection with another investigation in the Chicago Laboratory.¹⁰

(3) *Color-naming.* Twelve cards containing 100 colors each were prepared. The colors were one cm. square and placed one cm. apart on the cards. Green, red, yellow, black, and blue were the colors used, 20 of each to a card and in random order. The cards were presented face downward to *S* who turned them over and named the colors as rapidly as possible. The cards were not of equal difficulty; some of the combinations proved easier than others. For this reason and due to the fact that we presented the cards in regular order every day, we could not construct representative fatigue curves for this test. We recorded the time that it took to name the 100 colors on each card, however. Errors consisted in skipping colors or misnaming them. (Although we recorded errors, we shall not present them with our results; they seem not to have been influenced by the fast.) In case *S* corrected himself *E* made note of the fact by a symbol. This test was adapted from Kleitman's experiment on sleep.

(4) *Backward reading.* This test was suggested by the Robinson and Herrman experiment on insomnia, to which reference has already been made. Patrick and Gilbert were apparently its originators. Three magazine articles each for *A* and *B* were taken from a current periodical and mounted on cards. Each article was of 12-point type, 1000 letters in length. Each was read every third day.¹¹ *S* began at the bottom of the article and named from right to left the letters as they appeared in the words. He advanced to the top of the article by taking each successive line upwards. Results consisted of the time to read the article. Errors of both the corrected and uncorrected type were also recorded, but they seem to have been unimportant. Because several of the tests were trying on his eyes, *C* asked to be excused from taking this test.

(5) *Steadiness.* The device described in Whipple's *Manual*¹² was used to measure the changes in steadiness that took place. *S* was required to hold the pointer for 30 sec. each in the 3rd, 5th, 7th, and 9th holes of the metal plate. These holes were 16, 11, 9, and 7 sixty-fourths of an inch in diameter. The needle pointer was of standard design. The interval of rest between the pointings was 30 sec. Both hands were tested. The results consisted of the errors made in touching the walls of the metal plate with the pointer. These were recorded automatically by electrical connection with a clock-counter. A strong current was used, sufficient to 'carry through' with the least contact, but of insufficient intensity to injure the mechanism of the clock. To decrease noise the clock was embedded in a box of sawdust. Each click was reduced to a dull thud.

S was seated at a table in a comfortable manner, with body tilted slightly forward. He was not permitted to hold his elbow against his side. When he was in position a switch was thrown at the signal 'go,' completing the circuit. In the interval of rest *S* always held the pointer in the hand that was being tested. Otherwise he disposed of his time as he desired.

(6) *Visual acuity.* In lieu of some standard test on visual acuity that fulfilled the requirements of this experiment, the following was constructed. Five rows each of 12-, 10-, 8-, 6-, and 5-point type, 25 letters to a row, were printed on a card. Letters that looked somewhat alike appeared next to each other in a mixed fashion. For instance, the letters P B R and O D G C appeared in different patterns, unspaced and in capitals, along with

¹⁰E. S. Robinson and A. G. Bills, Two factors in the work decrement, *J. Exper. Psychol.*, 9, 1926, 415-443.

¹¹I cannot commend this procedure for eliminating the effects of practice. Only one card should have been used.

¹²G. M. Whipple, *Manual of Mental and Physical Tests*, I, 1914, 155-160.

most of the other letters of the alphabet. The purpose was to have a test of some length where fine visual discrimination could be measured.

This card was placed under a light in a dark-room. A reflector shielded the light, permitting no glare to the *Ss* vision. A rheostat was inserted to cut down the current. A translucent white light ('milk glass') of 50-candle-power, using 16/50 amperes, was employed. *S* sat with his head against a head-rest; his eyes were 42 in. from the card. This distance and the amount of current used were determined by the available space in the dark-room. *E*, with the aid of a flashlight behind the curtain, checked *S*'s performance on a duplicate of the test.

S was asked to read the letters as steadily as possible, taking only the second, third, and fourth lines of each size of type.¹³ The test began with the largest type and proceeded downward, including the smallest type; *S* read from left to right. He indicated by a short guttural "umph" a letter that he could not identify, and proceeded to the next. *E*, with the aid of a long handle, opened and closed a small door covering the card, when necessary, during the test. A few seconds were taken between readings on each size of type to record time and omissions. *E* was never visible to *S* during the test.

This test required some time to prepare, and as a result did not get the benefits of a long practice period prior to the fasts. It was completed and used for the first time about 10 days before the first fast. Without anticipating our findings, we may say that the results secured were decisive, in view of the post-fast performances of all *Ss* in this test.

(7) *Equilibrium*. This test is another measure of steadiness, in this instance of the ability to stand at 'attention.' A device known as the ataxiagraph, mentioned and illustrated by Doll,¹⁴ was constructed. It consisted of a glass cylinder fastened upright to a head-band. A delicate spring was enclosed within the cylinder. From the end of the spring a stylus projected through a small hole in the stoppered cylinder.

This 'crown' was buckled on the head, the stylus pointing upward from the forehead. A fixed support held a metal plate upon which sagged rather loosely a smoked paper. When *S* was placed in position this plate was lowered on a standard until the stylus touched the smoked paper. It thus recorded the movements of the head or body by a tiny mark upon the smoked surface.

The position of the *S* was approximately at 'attention.' The feet formed an angle of 45-50°, the heels were together, and the body comfortably erect. The arms extended downward by the sides, palms inward. *S* stood in this position for 2 min. blindfolded and 2 min. with vision. Between the conditions there was a rest interval of 2 min. during which the *S* was seated. The order of the conditions was alternated from day to day.

The extreme distances from left to right and back and forth over which the stylus moved constituted the measurements for this test. These measurements were taken in mm. by the use of a needle-point divider, the spread being read from a steel scale.

General procedure. Preceding the experiment every *S* agreed that he would do his best very day throughout the entire experiment and endeavor to keep an open mind as to the outcome. No *S* was permitted to know his own performances from day to day on any test.

A and *B* performed the first four tests, namely, arithmetic, writing, color naming, and backward reading, in their home. They acted as *S* and *E* in turn for each other in all tests except that of visual acuity. In order to make this possible duplicate forms of some of the tests were constructed.

¹³Thus a line was always immediately above and below the one being read, a fact which would not have been true if the first and last lines had been read.

¹⁴E. A. Doll, *Clinical Studies in Feeble-mindedness*, 1917, facing p. 66.

Different materials were used for backward reading. While *S* read the material backward, *E* followed, using a copy on which the material was read forward. *E*'s copy was in large type and the words were not spaced, so that it looked to the *E* like a pied paragraph.

These 2 *Ss* used the same arithmetic problems, but rarely solved the same set from the 400 on any given day. Whenever this did happen, as it was bound to when *A* solved 20 and *B* solved 40 problems each day, it was rarely, if ever, noticed by the person acting as *S* after having acted first as *E*. These *Ss* never memorized the answers to any problems.

For the color-naming test the names of the colors were typed in large print for the benefit of *E*. This made it easy to follow *S*'s reactions.

It can be seen that these three tests are probably the only ones wherein *S* could have any advantage by having acted as *E*. We believe that the precautions explained above reduced to a minimum, if indeed they did not entirely eliminate, any advantage that might accrue to one acting the rôles of both *S* and *E*.

The writer always acted as *E* for *C* except in the test of visual acuity. A graduate student in psychology, Miss Marian Geohegan, to whom we are greatly indebted, acted the part of *E* in this test. All tests except the four given at home, were given in the Psychological Laboratory.

The results secured during the practice period were graphed by the *E*. The four major tests, arithmetic, writing, color-naming and backward reading were the ones especially observed. The fast was not begun in any case until the *S* had apparently reached a level of performance and remained there for several days. Dr. E. S. Robinson advised *E* as to the time when the fast should begin. The experiments were thus subjected to better control by having an experienced referee who was not a subject.

As a matter of convenience the results from testing *C* are graphed as if the tests were given every other day. As we have explained previously, only 48 out of the 110 days of the experiment were testing days, so this is not quite true.

RESULTS

(1) *General tendency to lose.* In the four major tests there was a general tendency for the *Ss* to 'perform' at a lower level of efficiency during the period of fasting. This tendency was more conspicuous in the case of the longest fast, but was generally characteristic of the shorter ones as well.

Figs. 1-5 show the performances of the 3 *Ss* throughout the experiment. In estimating the effects of the fast the early portions of the graphs can be ignored; these sections of the curves illustrate mainly the marked influence of practice upon the activities in question. When, hereafter, we make reference to the pre-fast performance, we are considering the relatively flat sections of the curves just preceding the fast. The cross-bar designates the point at which we assume practice to have become a minor factor. The broken portion of each curve represents performance during the fast.

Fig. 1 shows that *C* lost considerably in the time required to perform 40 addition problems when enduring the fast in comparison with the pre-fast and post-fast performances. For about 15 days he performed as well during the pre-fast period,

but during the next 10 days his rate of performance was definitely decreased. During the last week of the fast he returned about to the level of the pre-fast performance.

The curves for *A* and *B* show little more than daily fluctuations in performance during the fast. Especially is this true in comparison with the pre-fast section of the curves. The stimulating effects of food after a fast, indicated by most of the tests, will be discussed in a later section.

Fig. 2 shows that both *A* and *C* suffered a distinct loss during the fast in ability to write, as measured by the number of letters

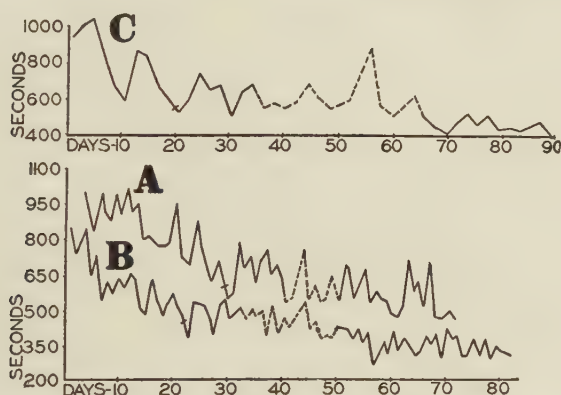


FIG. 1. ARITHMETIC. Performances of *A*, *B*, and *C*, before, during and after a 10-, 17-, and 33-day fast, respectively. Pre-fast begins with black bar; fast is in dotted line

written. After the first 2 days of fasting the output of these two *Ss* gradually decreased. On the last 2 days of the fast *A* showed a tendency to recover some of the losses sustained. Toward the close of the fast *B* suffered a most marked loss of output. His strong physique doubtless was responsible for his ability to perform at a high level for almost 2 weeks during the fast.

Fig. 3 shows very clearly that *C* took a much longer time to name 1200 colors during his fast than he did previous to it or afterward. The differences between the pre-fast performances and those during the fast are much more marked in his case than they are for *A* and *B*. The after-fast acceleration again was great with this *S*. The only conspicuous result shown by the curve for *B* is the after-fast acceleration. The performances of *A* show little variation from normal.

No graphs are presented for backward reading. Of the two *Ss* taking this test, *A* reacted more slowly during the fast than

before or afterward, while *B* was apparently unaffected by the fast, though he did show a post-fast improvement. These facts are clearly enough shown in Tables I and II.

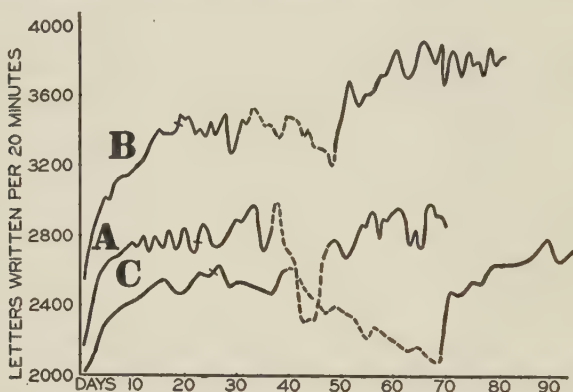


FIG. 2. WRITING. *A*, *B*, and *C*, before, during, and after a 10-, 17-, and 33-day fast, respectively. Pre-fast begins at black bar; fast is broken line

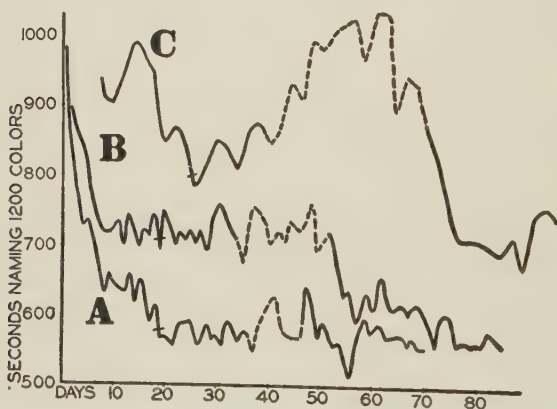


FIG. 3. COLOR NAMING. Performances of *A*, *B*, and *C*, before, during, and after a 10-, 17-, and 33-day fast, respectively. Pre-fast begins at black bar; fast is broken line

Fig. 4 shows the relative time consumed in naming the letters in the visual acuity test. Every *S* proceeded at his own rate during this test. The graphs show very clearly that all *Ss* took more time to perform during the fast than either before or afterward, in spite of the fact that the task performed after

the fast was somewhat greater than that preceding or during the fast, *i.e.* the total number of letters read per test was greater after the fast.

Tables I, II, and III show the average performances of *A*, *B*, and *C* in all of the tests. The performances are grouped into the three main periods of experimentation—the pre-fast, the fast, and the post-fast. The pre-fast is that period before the fast but following the pronounced practice effects of the very early performances (see cross-bars on graphs). The averages show a general tendency of the *Ss* to lose in efficiency during the fasts. The marked exceptions to this tendency will be given separate consideration.

TABLE I

PERFORMANCES OF *A* IN TESTS PRECEDING, DURING AND FOLLOWING
A 10-DAY FAST.

Abbreviations: " = seconds; c = errors (contacts); mm = millimeters

Tests			Pre-fast	Med. Dev.	Fast	Med. Dev.	Post- fast	Med. Dev.
1. Multiplication			675.0"	44.5	609.3	46.5	574.5	70.2
2. Writing (letters)			2813.4	68.6	2576.71	69.5	2834.3	84.7
3. Color-naming			575.3"	14.3	584.2	16.2	578.1	18.9
4. Backward reading			333.2"	6.2	364.7	15.5	309.3	18.3
5. Steadiness (hands)	Right		14.45c	6.4	13.8	5.38	11.52	6.5
	Left		15.55c	4.4	18.5	5.00	13.56	3.5
	Total		30.00c	6.0	32.3	12.88	25.08	10.1
6. Visual acuity	Letters		356.0	3.0	355.0	2.0	358.9	2.1
	Time		338.0"	8.0	394.0	34.5	316.4	32.6
7. Equilibrium	Blindfold	L-R	37.7mm	2.3	34.4	9.0	38.9	8.9
		B-F	44.8mm	5.2	46.1	6.4	58.0	8.0
	Seeing	L-R	30.5mm	9.5	29.8	3.8	30.9	6.9
		B-F	36.1mm	13.1	36.8	5.3	45.5	10.5
	Totals	Blindfold	82.5mm	9.5	80.5	3.5	96.9	16.9
		Seeing	66.7mm	12.7	66.5	9.0	76.4	13.6

(2) *Increase in steadiness.* Fig. 5 shows graphically the results of the Whipple test of steadiness. The curves have different ordinates to prevent superposition but have the same abscissae. The results for both hands are combined in the interest of simplicity. Separate graphs of the results from testing the two hands showed no consistent differences between the performances of the right and of the left hands. The averages show only slight differences between the two hands, as can be seen from Tables I-III. The curves for *B* and *C* will be discussed first.

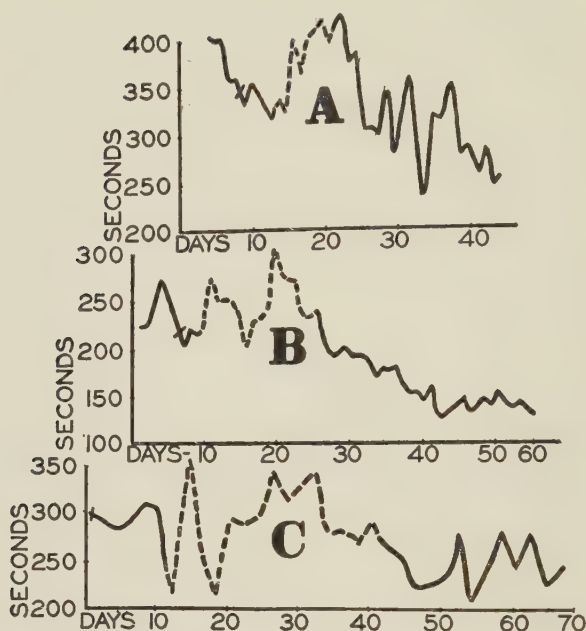


FIG. 4. VISUAL ACUITY. Performances of A, B, and C, before, during, and after a 10-, 17-, and 33-day fast, respectively. Pre-fast begins at black bar; fast is broken line

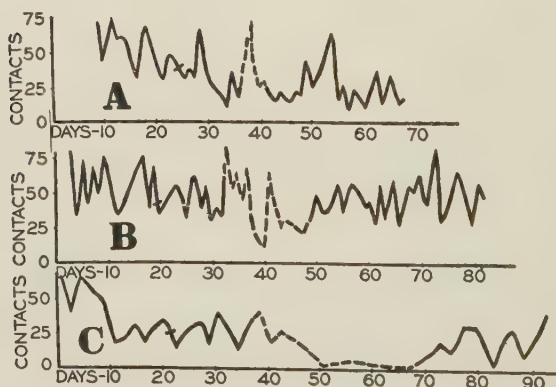


FIG. 5. STEADINESS. Performances of A, B, and C, before, during, and after a 10-, 17-, and 33-day fast, respectively. Pre-fast begins at black bar; fast is broken line

B and *C* show a gain in steadiness when the results during the fasts are compared with the other conditions. Due to the variations in the curve for *B* the gain is not so clearly shown as it is for *C*. The averages in Table II show that *B* did make a small gain during the fast in this test, though his gain is not statistically certain.

The gain of *C* is very conspicuously shown by the graph, Fig. 5. After the first few days (tests were given about every other day) he showed a steady increase approaching almost zero errors as the fast continued. He remained at this low level

TABLE II

PERFORMANCES OF *B* IN TESTS PRECEDING, DURING AND FOLLOWING A 17-DAY FAST.

Abbreviations: " = seconds; c = errors (contacts); mm = millimeters

Tests		Pre-fast	Med. Dev.	Fast	Med. Dev.	Post- fast.	Med. Dev.	
1. Multiplication		499.9"	26.9	459.9	44.1	369.9	38.9	
2. Writing (letters)		3413.7	51.5	3380.9	82.9	3728.2	87.8	
3. Color-naming		722.9"	15.9	724.7	17.3	610.6	14.4	
4. Backward reading		264.5"	6.5	262.4	7.6	222.2	3.8	
5. Steadiness (hands)	Right	25.2c	3.8	19.0	11.0	22.9	4.9	
	Left	19.2c	5.8	23.1	8.1	24.5	5.5	
	Total	44.4c	11.4	42.1	17.1	47.4	9.6	
6. Visual acuity	Letters	374.4	0.4	373.4	1.6	374.9	0.1	
	Time	213.7"	9.3	249.2	21.2	159.6	21.0	
7. Equilibrium	Blindfold	L-R	33.9mm	12.0	30.1	5.1	35.1	7.5
		B-F	34.1mm	5.1	40.2	8.8	44.2	8.0
	Seeing	L-R	29.1mm	5.9	28.5	3.5	30.2	8.7
		B-F	32.7mm	3.7	38.2	10.2	39.3	7.3
	Totals	Blindfold	68.0mm	13.5	71.0	11.0	79.2	11.5
		Seeing	61.9mm	8.8	66.7	14.3	69.6	14.6

until the completion of the fast when, as can be seen by the curve, he became less steady. It was impossible to keep this *S* from knowing that he did better during the fast. Although *S* mentioned the fact several times during the fast, *E* never discussed the matter with him.

Table III shows that *C* made on the average about 14 less errors during the fast than before it. When compared with the post-fast the errors are about 10 less. The corresponding gain for *B* (Table II) is not so marked.

Table I shows that *A*, who underwent the shortest fast, suffered a loss in steadiness during the fast. Taking the average

of the first 7 days of fasting, every *S* showed a distinct loss over the two other conditions. Had we stopped the tests at the end of one week of fasting, and secured the same data for the post-fast performances of all 3 *Ss*, we could have said that the fast caused a marked falling off in steadiness for every one. The curves show that all *Ss* increased in steadiness after the first week of fasting, except for one bad day for *B*.

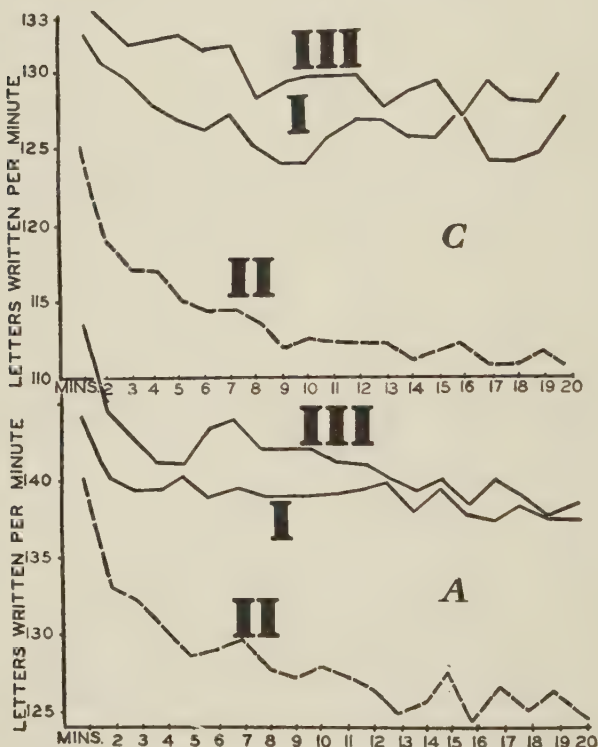


FIG. 6. WORK-CURVES. Curves of A and C for writing in the pre-fast (I), the fast (II), and the post-fast (III) periods

The other form of steadiness, *i.e.* equilibrium, was little affected by the fast. See Tables I-II.

(3) *Fatiguability*. Fig. 6 shows the work-curves of A for the writing tests. One curve is shown for every one of the three phases of the experiment. These curves show the general ten-

dency of *S* to become more fatigued as the day's task progressed. The pre-fast curve shows that he performed at a level considerably higher than that of the fast, but the important fact illustrated is the greater fatiguability during the fast. *A* began writing about 140 letters per min., on an average, and finished the day's task at the rate of 125 letters per min. During the pre-fast and post-fast the corresponding losses were a little more than half this amount.

The curves for *C*, Fig. 6, represent almost exactly the same thing, except for his tendency to perform at a little higher level during the last minute.

TABLE III

PERFORMANCES OF *C* IN TESTS PRECEDING, DURING AND FOLLOWING
A 33-DAY FAST.

Abbreviations: " = seconds; c = errors (contacts); mm = millimeters

Tests			Pre-fast	Med. Dev.	Fast	Med. Dev.	Post- fast.	Med. Dev.
1. Addition			568.3"	37.2	559.5	40.5	451.3	19.3
2. Writing (letters)			2533.0	53.0	2306.9	127.1	2619.6	74.4
3. Color-naming			841.8"	28.3	975.3	66.3	742.5	30.5
4. Steadiness (hands)	Right	12.9c	7.0	5.0	4.0	9.2	3.8	
	Left	11.8c	4.0	5.8	4.8	11.2	4.2	
	Total	24.7c	8.0	10.8	8.8	20.4	7.4	
5. Visual acuity	Letters	357.3	4.0	361.0	3.0	365.5	5.0	
	Time	299.5"	9.5	290.0	25.0	247.1	19.1	
6. Equilibrium	Blindfold	L-R	25.7mm	2.7	25.6	6.6	24.4	4.4
		B-F	41.1mm	1.9	32.9	6.1	32.5	4.5
	Seeing	L-R	22.4mm	5.4	22.5	5.5	20.2	4.2
		B-F	32.2mm	9.2	32.5	7.5	37.5	4.5
	Totals	Blindfold	66.8mm	4.2	58.5	9.5	56.9	4.9
		Seeing	54.6mm	10.6	55.0	11.0	57.7	3.7

The curves for *B*, which are not shown, indicate that his performances during the pre-fast and the fast went on at about the same level in this test. He showed less susceptibility to fatigue than the others.

(4) *After-fast acceleration.* With few exceptions, the after-fast performances were on a higher level of efficiency than either of the other conditions. This relationship is true of all tests except those in which a gain was made by the *Ss* during the fasts. It also applies more to *B* and *C*, who endured the long fasts, than to *A*, who fasted only 10 days. Although *A* showed a gain in the post-fast over the two other conditions in all but the

color-naming and equilibrium tests, her gains are not so outstanding as those of the two other Ss. The curves that most conspicuously show the acceleration of after-fast performances are Figs. 2 to 4.

It may be possible that the effects of practice are still operating to some extent in some of the tests. But Figs. 2, 3, and 4 seem to show an additional effect, especially for *B* and *C*. Fig. 2 shows that these Ss performed in writing almost immediately after the fasts at a higher level than ever before. Fig. 3 shows that these Ss began naming colors a few days after the resumption of food at a rate never before attained. *A*, and especially *B*, spent much less time in reading more letters, as shown by Fig. 4, immediately after the fast was concluded. These facts lead us to believe that there is a marked after-fast acceleration due to the stimulating effects of food.

Carlson¹⁵ relates some of the after-effects of fasting for a few days at a time. Speaking of his physical and mental condition after a 5-day fast he says, "the writer felt as if he had had a month's vacation in the mountains. The mind was unusually clear and a larger amount of physical and mental work was accomplished without fatigue." All of our Ss spoke of the unusually heightened feelings they experienced during the after-fast period.

(5) *Decrease in weight.* Table IV shows the weights of the Ss at the beginning and at the close of the fasts.

TABLE IV
WEIGHT LOSSES DURING FAST

S	Weight		Loss		
	at beginning	at close	pounds	%	Pounds per day
<i>A</i>	121.3	109.1	12.2	10.1	1.22
<i>B</i>	166.3	144.1	22.2	13.4	1.31
<i>C</i>	148.7	118.6	30.1	20.3	0.91

Twenty-three days after the fast *A* had not regained her full weight. Since this was June 19, and she was only 4.7 lbs. under-weight, it may be said that she was not far from normal. On the 19th day after concluding his fast *B* was 0.5 lbs. over-weight. *C* was 0.2 lbs. under-weight 29 days after concluding his fast, but since this was on July 29, almost mid-summer, it may be said that he was slightly over-weight.

CASUAL OBSERVATIONS

Increase in smell sensitivity. The most outstanding observation made by the Ss enduring these longer fasts, was the marked increase in the ability to detect odors during the fasts. Food, we believe, could be detected at a greater distance. *C*

¹⁵A. J. Carlson, *Control of Hunger in Health and Disease*, 1916, 137.

reported that perfumes and even body odors were keenly noticed by him when he met or passed people on the streets during his many walking trips while fasting. *B* refused to drink the city water after a few days of fasting because of the offensive odor of the chlorine in it, a fact rarely noticed at other times. (The office of the City Engineer informs me that a chlorine gas is used in the city water.) *B* purchased a supply of spring water to use for drinking purposes during the last 10 days of the fast.

Marsh hints at results of this nature when he says that taste and smell "were tested for two weeks and dropped, due to the delay entailed; but the results would have proven as interesting as any, had this section of our plan been completed."¹⁶ Langfeld says that Levanzin called his attention to the fact that "heightened sensitivity for odors during his first fast made walking on the streets positively unpleasant."¹⁷

It is a well-known fact that hunters deny food to their dogs for several hours preceding a hunt. This is a common practice with fox hunters in a certain section of the South. The popular opinion is that the animals do better when the stomach is empty. Without denying the value of hunger as a stimulus to action, it seems probable that the animal's olfactory sense is much keener too. Thus the opinion that a hungry animal can follow a 'cold' trail better than when he is well-fed may, after all, have some basis in fact.

It was originally intended to secure some measure of smell sensitivity during the experiment, but it was difficult to get a test that met all of the requirements of the problem without over-loading the program. It is hoped that objective results will be obtained by some experimenter in the future on this apparent increase in sensitivity to odors.

Dreams. Dreams were prominent in only the longest fast. Only a few were reported by *A* and *B*. These were either very hazy and disconnected or were remotely related to food. *C* reported several dreams about food after three weeks of fasting, but none was very striking.

Sexual feelings. About a week after *C* had concluded his fast, the writer asked him about the effects of fasting on the sexual impulses. He substantiated what the writer had already observed, that food after a fast of some length tended to accelerate the activities of the sexual organs. *C* had noticed this, also, at the conclusion of previous fasts.

Someone has suggested that this condition is due to eating considerably more meat than ordinarily. It is quite possible that an increased meat diet will serve thus as a stimulant after a fast. It is more reasonable to assume that an increased sexual tone would naturally accompany the greatly increased body-tone that normally follows a fast. That the entire body-tone was heightened after the fast was reported by all 3 *Ss*. This increase in sexual tone should also be thought of in relationship to the high mental efficiency shown by certain of the tests.

¹⁶*Op. cit.*, 438.

¹⁷*Op. cit.*, 49.

Miscellaneous. The bodily temperature of *A* and *B* remained almost unchanged throughout the fasts. Respiration increased slightly. Both measurements were taken after 30 min. rest in a prone position. As *C* had endured several fasts it was thought unnecessary to observe him so carefully in these respects.

Every visit to the laboratory and the return home required the *Ss* to climb several flights of stairs. After about 10 days of fasting the climbing did not cause the limbs to ache as much as it did during the earlier part of the fasts.

Only one *S* was an occasional smoker. He smoked freely during the first two days of the fast, began to lose the taste for tobacco on the third, and gave it up completely on the fourth day.

CONCLUSIONS

The conclusions reached as a result of this experiment are as follows.

(1) The so-called 'mental' out-put is generally decreased during a long fast.

(2) A fast of more than a week's duration definitely increases steadiness of hand.

(3) A subject fatigues more rapidly during a fast than normally, when the task is of considerable length and homogeneity.

(4) Performance at some tasks after a long fast is much more efficient than normally, an effect which can hardly be attributed to practice alone.

(5) In casual observations it was noticed (a) that the smell sensitivity is greatly increased during a long fast; and (b) that sex feelings in males are considerably accentuated when eating is resumed after a long fast.

EFFECTS OF SHORT FASTS

In order to test the effects of short fasts *A* and *B* of the preceding experiment, and a new subject, *D*, a Chinese male graduate student, fasted one day out of every six. *A* and *B* fasted 7 times and *D* fasted 5. A period of about three weeks practice preceded the fasts. Arithmetic, writing, and the two tests of steadiness were used. These are identical with those used in the preceding experiment, and were given in the same way.

The results on the days of fasting were compared with those secured on the 3 days previous to and the 3 days following the days of fasting. Each fast was endured on a different day of the week.

No definite results were secured. On some fast days the *Ss* did better than on the pre-fast or post-fast days, and on others decidedly poorer. It was almost impossible for the *Ss* to main-

tain the same attitude toward the experiment on the day of the fast as on other days. This conscious factor undoubtedly did much toward obscuring the real results.

Wada¹⁸ has shown a close relation between hunger contractions of the stomach and best performances in mental tests. She tested almost continuously for 10 to 12 hrs., after the Ss had gone without food for the greater part of a day. Almost without exception, the best results accompanied hunger contractions of the stomach. Since our tests were all performed in about 1½ hrs. work a day it is readily seen where our difficulty lies. Although our Ss were, in a general sense, hungry on the foodless days, we can have no assurance that there were hunger contractions during the actual test period.

We see no way of reconciling our negative results with the positive results obtained from short fasts by Weygandt and by Aschaffenberg.¹⁹ Both of these students found short fasts to have markedly deleterious effects.

¹⁸Tomi Wada, An experimental study of hunger in its relation to activity, *Arch. Psychol.* 8, 1922, No. 57.

¹⁹Cited by Langfeld, *op. cit.*, 47.

SENSITIVITY TO ODORS AND OTHER PHENOMENA DURING A FAST

By JOHN ARTHUR GLAZE, University of Michigan

In a previous experiment it was found that some *Ss* showed a marked increase in sensitivity to odors during a fast.¹ This was particularly true with the *Ss* that endured long fasts of 17 and 33 days. The observations of Marsh, as we mentioned in the earlier study, confirm these findings.² As neither Marsh's nor our study was designed to test this phenomenon, the following study was undertaken.

TESTS WITH ODORS

Apparatus. The Zwaardemaker olfactometer was employed in the experiments. It consists of "one tube with a curved end to be inserted in the nostrils, and of a second tube of larger size containing an inner lining of the substance to be investigated which slips over the former. The amount of stimulation is measured by the area of the outer tube exposed beyond the inner."³ As a matter of convenience we shall call the tube containing the substance the *x* tube, and the inner conducting tube that extends through the shield to the nose the *y* tube. The end of the *y* tube was covered by a smooth nickel cap so that it closed the side of the nose in which it was placed. The *S* always closed the other nostril with a finger during the test.

Seven odoriferous tubes were used. The liquid odors were diffused through warm paraffine, poured into tube *x*, and a hole the size of tube *y* was bored through the paraffine after it had hardened. The ends of the *x* tubes were sealed with tin foil so as to hold the substances and also to prevent wear at the ends. A hole, the size of tube *y*, was of course made in the center of the tin foil caps.

Stimuli. The substances used were asafoetida, benzoin, cedar wood, rubber, balsam, beeswax, and Russian leather. The first was very weak, the last very strong, the others ranged in strength between these. When not in use the tubes were kept in screw-top glass containers.

Procedure. Several *y* tubes were used, and they were thoroughly washed and dried at the end of every test. When tube *x* was placed on tube *y* it was shoved beyond the end so that tube *y* projected out of tube *x*. *S* then blew the air out of *y* and, after a short wait, placed the nickel cap over the end of the *y* tube and the experiment began. Tube *x* was exposed slowly until *S* indicated that he scented the odor. Then the *x* tube was shifted in the other direction until *S* reported that the odor was lost. The mean of these two points was taken as the *S*'s limen. Only in a few cases were these deviations large, and these few cases were more apt to occur with the strong and weak odors than with those of intermediate strength. It took from 20-30 min. to test an *S* with all 7 odors, consequently a rest

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¹J. A. Glaze, Psychological effects of fasting, this JOURNAL, 40, 1928, 236-253. Cf. especially 250 f.

²H. D. Marsh, Individual and sex differences brought out by fasting, *Psychol. Rev.*, 23, 1916, 438.

³W. B. Pillsbury, *The Fundamentals of Psychology*, 2nd ed. 1922, 180.

period of about 5 min. was usually interpolated between the fourth and fifth tubes. Sensitivity was measured by the number of mm. of the odoriferous material exposed.

Subjects. Two *Ss* were used: B, the writer, who served in the previous experiment; and D, a 10-yr. old boy, a patient in the University of Michigan Hospital. Eight weeks before the beginning of the experiment, D was admitted to the hospital and shortly afterward was operated on for tonsils and adenoids. He was able to walk from the ward to the laboratory where the tests were held.

D was up to grade in school subjects, had a mental age on the Binet test of $9\frac{1}{2}$ yrs., and I.Q. of 87. He was decidedly overweight for his age and was willing to fast to reduce. Indeed, he reported that he had fasted before, and that he had gone as many as 5 days without food so as to get rid of his excess weight—a subject about which he was sensitive.

B fasted for 10 days, and D for 5 days. As in the earlier study, a practice period preceded the fasts. In general the pre-fast and post-fast test periods were of about the same length as the fast periods. Neither *S* showed signs of a cold throughout the experiment, and D never left the hospital.⁴

TABLE I

SENSITIVITY OF B AND D TO ODORS DURING THE PRE-FAST, FAST, AND POST-FAST PERIODS

Sensitivity expressed in mm. of odoriferous material exposed

Pre-Fast				Fast				Post-Fast			
B		D		B		D		B		B	
day	mm.	day	mm.	day	mm.	day	mm.	day	mm.	day	mm.
1	*	1	*	11	60.1	7	19.0	21	29.3	12	25.3
2	69.0	2	53.0	12	34.0	8	6.9	22	22.0	13	18.1
3	56.4	3	22.6	13	25.4	9	— 0.6	23	41.9	14	21.9
4	44.4	4	14.6	14	13.4	10	— 1.4	24	26.7	15	28.9
5	37.7	5	20.9	15	— 2.1	11	— 1.7	25	26.6	16	48.9
6	48.1	6	36.7	16	— 9.7			26	37.0		
7	63.3			17	— 3.7			27	31.6		
8	42.3			18	0.6			28	38.4		
9	70.0			19	0.7						
10	66.4			20	— 1.7						

*Practice, no data taken.

Results. The results are shown in Table I. Minus values are shown better after the second day of D's fast and after the fourth day of B's fast. This means that sensitivity was so acute that the *Ss* were able to scent some of the odors before the *x* tubes were drawn out and exposed in the *y* tubes. In the case of Russian leather and part of the time in the cases of beeswax and balsam this was quite pronounced. At first *E* was suspicious that the *Ss* had anticipated the odor, but when the report was verified on successive days there remained no doubt but that the first measures were accurate.

⁴I have Dr. David M. Cowie and his assistants of the University Hospital staff to thank for their kindness in allowing me to use this *S* and in giving instructions to the diet kitchen to withhold the plate from him during the 5 days.

It must be said that tube *y* did not completely fill tube *x*. Six of the *y* tubes were so nearly the same diameter that they were used indiscriminately with any of the 6 odors. The seventh *y* tube was slightly smaller than the others and was always used with the rubber *x* tube. Minus values mean then that *S* was able to scent the odors when none of the *x* tube projected beyond the end of the *y* tube. Russian leather, beeswax, and balsam had large minus values whereas asafoetida was exposed as much as 50 mm. on some days during the fast to reach the sensory threshold. Benzoin was also weak. The averages of the 7 odors, given in Table I, do not show how difficult it is to sense some of the stimuli.

Asafoetida, rubber, and benzoin were not scented at times during the pre- and post-fast periods even when they were exposed at their full strength—100 mm. We counted these

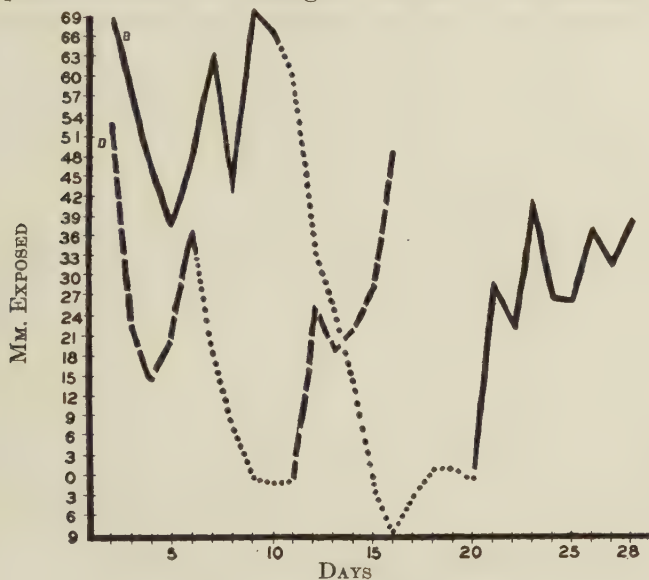


FIG. 1. SENSITIVITY TO ODORS
Broken lines show results of the fasts

cases, however, as if they were sensed at 100 mm. Ostensibly this diminishes the ratio of increased sensitivity during the fast, since we do not know how much of an increase was necessary to bring these odors to the sensory threshold. Before the fast, B was unable to scent two and sometimes three of these odors when fully exposed, while after the fast he never scented asafoetida at all. In the case of D a smaller number of failures was found. This observation raises the old question whether children are more sensitive to odors than adults.

Fig. 1 illustrated the results of Table I. The dotted lines show the results during the fast. The sixteenth day for B is not quite so low as it should be in the figure.

The literature on experiments of this kind is meager. Most of it is the by-product of experiments similar to Marsh's and our own earlier study. Hoelzel and Kleitman, for example, discuss the increased sensitivity of the digestive tract in connection with increased gastric acidity during a fast.⁶ They show that the digestive tract is more sensitive to pain during and immediately following a fast than at other times.

That this sensitivity should be reflected in the upper part of the digestive tract seems reasonable. The close relation of taste and smell is well known. In the case of leather and beeswax a burning sensation was noticed in the nasal tract. This did not apparently extend beyond the throat, in the region of the thorax. The pleasant odors of balsam apparently did not extend so deeply, but filled the nasal cavity with a fullness unlike that felt at other times.

In the absence of more experimental work of this kind it is difficult to formulate a theory as to why one should be more sensitive to odors during a fast. As between central and peripheral mechanisms we are inclined to attribute more importance to the latter. As between the rest of the alimentary tract and the olfactory bulbs the evidence, it seems to us, is also on the side of the latter, although the former may affect sensitivity in an indirect way. It has been suggested that the bipolar sensory cells located in the nasal mucous membrane are not necessarily more sensitive during a fast but the secretion covering the surface of the epithelium is more condensed. The gaseous particles entering into solution would make a more condensed solution and the corresponding increased stimulation may result.

It is well known that the greatest loss in weight during a period of fasting occurs in the first 3 or 4 days. The undigested food residue accounts for part of this, but not all. The liquid intake is greatly reduced during a fast, and the S has to force himself to drink a sufficient amount to meet the needs of the body. It is reasonable to suppose that the fluid about the mucous and serous cells that ordinarily covers the mucous membrane would be less with the decreased food and water supply. Hence the above assumption that the gaseous particles form a more condensed solution as they are absorbed by the liquid of the mucous membrane seems plausible.

OTHER TESTS

In order to check the result of our earlier study we employed four other tests with B. The first two were tests of equilibrium and steadiness—the same as were used in the earlier work and administered in the same way; the third was a memory test; and the fourth a relations test.

⁶F. Hoelzel and N. Kleitman, Some conditions affecting subjective and objective manifestations of hunger, *Arch. Inter. Med.*, 39, 1927, 710-740.

Equilibrium. The test of equilibrium, as before, gave no definite nor significant results (see Table II).

Steadiness. The steadiness test gave positive results after the first 5 days, i.e. a constant increase in steadiness as the fast progressed. These results are shown in Fig. 2. The averages in Table II show no gain during the fast because the marked unsteadiness the first few days of fasting tend to obliterate the actual increase. The holes in the metal plate, in this study, were somewhat smaller than in the earlier work, and that is why more errors are recorded in the present study. This change improved the test since the smaller the holes the more definite the results.

Memory. In order to measure more adequately the 'central processes' we prepared a test from our classification of nonsense syllables.⁶ We took an equal number of syllables from the 8 divisions that are represented

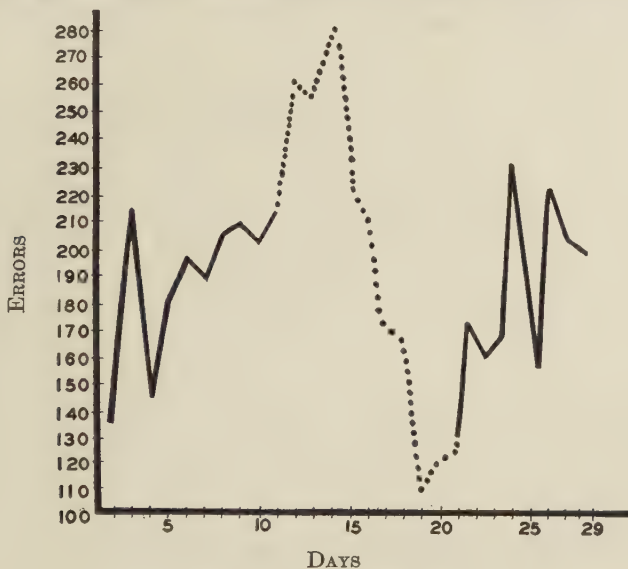


FIG. 2. STEADINESS TEST

Results of B. Broken lines show results of the fast

from 0-40% inclusive. These syllables are difficult to memorize and although meaning can be attached to some of them, most of them meant nothing for the Ss. Sixteen of these were used daily. They were presented one every 2 sec. for 10 readings at the beginnings of the group of tests. After an interval of 25 min., B was tested for the number retained. The interval was occupied with other tests arranged in such a manner that the olfactory test came before the test employing nonsense syllables. It is evident that we could stop the olfactory test at any place, to return to it later, without invalidating the results. In case of approaching adaptation an interval of rest was interpolated, but this never occurred in this test (olfactory) before the memory test. After a measure of the syllables retained we proceeded with successive presentations until all of the syllables were memorized. This gave us two sets of data, as can be seen in Table II.

⁶J. A. Glaze, The association value of nonsense syllables, *Ped. Sem.*, 35, 1928, 255-267.

The anticipation method was used. In view of the post-fast performance it can be said that nothing definitely in the way of increased mental acuity is shown during the fast.

Relation. A different process is represented by what we have chosen to call the 'relations test.' This test was made up of 5 consonants arranged in the form of a nonsense word, the following being examples: MWGKX, HGKZD, FNZKB, ZBJVN, VBGSX, ZSFMK, DGFBH. This type of test has been used before in the Michigan laboratory.⁷ The problem consisted in (a) indicating every 'word' that contained three consecutive letters not found in the preceding 'word,' and (b) indicating every two adjacent 'words' that had two consecutive letters in common. Every nonsense word was placed on a card, and 120 cards were presented every day, requiring 238 judgments. A 5-sec. exposure time was used. The results of this test are shown in Table II.

TABLE II

PERFORMANCES OF B IN FOUR TESTS DURING THE PRE-FAST, FAST, AND POST-FAST PERIODS
mm = millimeters movement; c = contacts

Test		Pre-Fast		Fast		Post-Fast	
		Av.	m.v.	Av.	m.v.	Av.	m.v.
Equilibrium	Blindfold	68.8 mm	8.8	66.6 mm	13.2	63.6 mm	13.1
	Seeing	56.2 mm	9.3	58.9 mm	10.4	44.5 mm	12.3
	Av.	62.7 mm	8.9	62.8 mm	6.0	59.7 mm	10.2
Steadiness (hands)	Right	84.4 c	15.0	93.7 c	32.9	91.6 c	16.4
	Left	98.4 c	12.2	94.5 c	24.1	95.4 c	10.5
	Av.	94.4 c	10.2	95.6 c	26.7	93.5 c	11.8
Memory	Savings	3.25%	1.9	5.1%	1.5	5.9%	2.0
	100% learning	12.6	5.1	10.4	2.4	8.5	2.5
Relations correct		92.79%	2.79	94.79%	2.25	98.28%	0.9

SUPPLEMENTARY EXPERIMENTS

(1) *Sensitivity before and after meals.* Evidence was gained in a supplementary experiment that showed Ss are more sensitive to odors before a meal than after it. Seven students in elementary psychology (6 sophomores and 1 senior) were tested with the 7 odors mentioned above. The Ss agreed to eat normally, to forego eating or chewing anything, or drinking anything that contained odorous or food substances between 8:00 A.M. and noon, the testing hour. A prohibition was also placed on smoking during these hours. After the first tests the Ss (only 2 a day could be tested) went to lunch and returned immediately afterward for the second tests. Each S was tested 6 days. The results of the first day, so as to eliminate the effects of practice, were discarded. The effects of practice, however, did not appear to be very marked. The results are shown in Table III.

All the Ss, with the exceptions to be noted, ate a light breakfast and a fairly heavy lunch. G.R. went without breakfast, and I.B. and D.H. ate light lunches, usually nothing more than a sandwich and a cup of chocolate.

⁷C. P. Wang, *The General Value of Visual Sense Training in Children*, 1926, 68.

(2) *Retest with D.* Six days after the experiment with D ended we decided to test him by imposing another 5-day fast. He was available and apparently willing, but was very anxious for the fast to end after it was under way. Four days of preliminary testing was done and 5 days follow-up. No significant results were secured.⁸

TABLE III

SENSITIVITY TO ODORS BEFORE AND AFTER THE NOON MEAL
Sensitivity expressed in mm. of odoriferous material exposed

Time of test	Ss						
	R.E.	R.S.	J.H.	H.A.	I.B.	D.H.	G.R.
Before meal	46.1	61.8	63.7	27.4	36.5	28.2	28.9
After meal	93.0	68.3	66.9	34.9	39.0	26.3	28.3

CONCLUSION

We conclude from the results of this study:

(1) That there is a marked increase in the sensitivity to odors during a fast.

(2) That steadiness, measured by the pointing test, tends to increase as the fast progresses.

(3) That the higher mental processes are not improved while the fast is in progress.

(4) That the most pronounced success, both in mental and muscular activity, is attained during the post-fast period.

⁸It was a mistake to use this S again so soon after the first fast. The intimacy of contact in the previous fast had its disadvantages. On the fourth day of the fast, for example, he came to the laboratory (on the same floor as his ward) chewing gum. He had secured it from some boys in his ward. He became somewhat secretive about the matter when questioned after the test. The results for the retest are: pre-fast, 32.4 ± 5.4 ; fast, 35.3 ± 3.5 ; post-fast, 34.1 ± 3.8 .

